DIVERTER DESIGN GUIDELINES FOR MECHANICAL GRAIN SAMPLERS

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DIVERTER DESIGN GUIDELINES FOR MECHANICAL GRAIN SAMPLERS[1]

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INTRODUCTION

Reliability of a grain sample must be accurate because the content of the entire grain lot is determined from the analysis of the sample. A moving stream of grain may be sampled by (1) a mechanical diverter-type, (2) a mechanical belt-type, or (3) a hand pelican sampler. The mechanical diverter-type, widely used for official sampling, is installed in a spout or at a belt end where, periodically, it cuts across the stream of moving grain to obtain a sample (*8*).[5]

Certain factors should be considered in collecting samples when using a mechanical diverter-type sampler:

1. Diverter speed must be uniform through the grain stream;
2. Diverter entrance must be wide enough to allow grain to enter without bridging, binding, or stopping;
3. Samples must not be contaminated with dust or bouncing grain;
4. Diverter must discharge rapidly to prevent overflow; and
5. Frequency and technique of sampling must correspond to the grain's flow rate (*4*).

The effective cutter width of the diverter depends on the horizontal velocity of the cutter relative to the vertical velocity of the falling grain. Figure 1 shows the geometric relation between actual cutter width (Wa) and effective cutter width (We) (*1*). If the horizontal velocity (V_c) is high in relation to the vertical velocity (V_s), effective cutter width available for grain collection is reduced

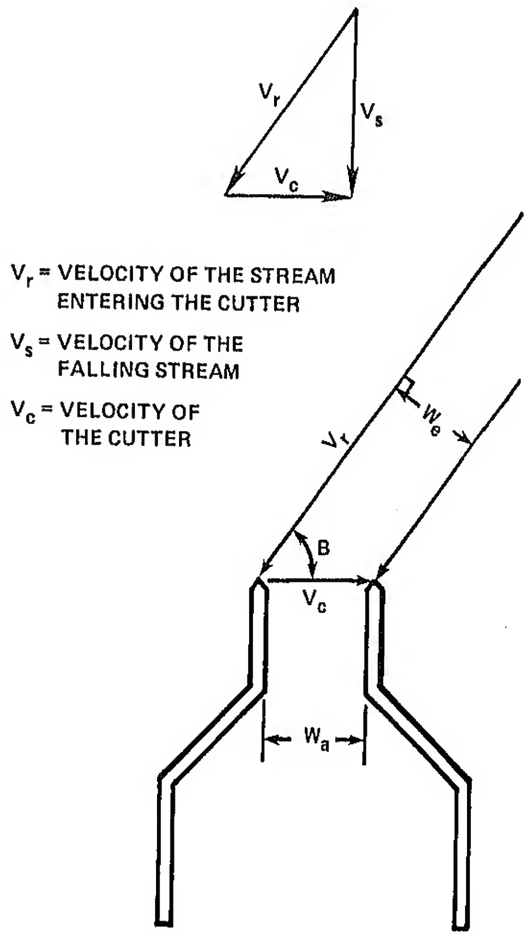

Figure 1.—Geometric relation between actual (Wa) and effective (We) cutter width.

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[5] Italic numbers in parentheses refer to Literature Cited, p. 18.

(We = Wa sin B). Joy Manufacturing Company, Denver Equipment Division,[6] (*4*) suggests that an effective cutter width should be three times the size of the maximum diameter of the particle sampled to allow kernels to enter with minimum collision.

Grain velocity at the diverter entrance affects size of the sample collected and amount of mechanical grain damage. Fiscus and others (2) developed prediction equations for grain stream velocities from 12- and 8-inch orifices at drop heights up to 85 feet. For drop heights less than 41 feet, orifice size had little effect on stream velocities, but from 41 to 85 feet, larger orifices produced higher velocities. Hawk and others (3) reported that the terminal velocities for soybeans were 6 percent faster than those for wheat or corn that were similar.

Using slow flow rates (under 4,000 lb/min), Kramer (*6*) tested various parameter effects on sample size. Two spout angles, 30° and 90° from the horizontal and at the same grain flow rate, produced samples of about the same weight. Kramer (7), in comparing sample sizes from reduced entrance widths that have the same diverter velocity and those from the same entrance width but having increasing diverter velocities, found that sample size decreased 30 to 50 percent for the tests as flow rates increased from 1,600 to 2,000 lb/min.

The objective of the research conducted at the U.S. Grain Marketing Research Center and reported here was to determine guidelines for optimizing the design for mechanical diverter-type samplers so they would collect an unbiased representative grain sample. Three commercial diverters were evaluated under actual sampling conditions and the results compared with those of earlier studies. Parameters that affect sample size were determined and bias from grain-flow patterns were observed within the diverter and around its entrance.

MATERIALS AND METHODS

Grains

Commercial wheat and corn were used and the same grain lots were used for all sample collections. The moisture content of the wheat was 12.2 percent and corn 11.8 percent. The grain was not cleaned during the investigation.

Sampling apparatus

Grain was dropped from a bin above the sampling apparatus to a bin below (figs. 2 and 3). Primary control for the grain flow was a sliding gate at ceiling level. A flow control valve, Syntron Division DFV 12 Style No. 117510, 22 inches below the sliding gate was used to vary the grain flow rate. The drop distance for the grain from the flow control valve to the diverter entrance was approximately 56 inches but depended on the diverter used. A 10-inch diameter tube extended from the flow control valve down 47 inches.

The drive mechanism used for these tests was a Gamet Automatic Sampler obtained from the Dean Gamet Manufacturing Company. It was powered by an electric motor-driven gear reducer, which reversed direction for each traverse. Its diverter velocity was controlled by gear ratio and motor r/min. The diverters were carried on a belt powered by the motor. This sampling apparatus could also be rotated 45° for sampling at various spout angles. A chute below the sampler channeled the grain to the lower bin.

Photographic equipment

Photography was used to determine grain velocities at the cutter entrance, flow patterns within the diverters, and flow patterns for various diverter entrance shapes. A Hycam Model K2OS4E 16-mm high speed motion picture camera with Kodak Ektachrome film (EF 7241-107-09) filmed the flow. A Milli-Mite timing light generator Model TLG-3 was added to the camera to place light marks on the film edge. The developed film was viewed with an Optical Data Analyzer Projector Model 224-A.

Sample cutting device

The sample cutting device was designed to produce the effect, not a model, of a diverter passing through a grain stream (figs. 4 and 5). A 10-inch diameter hole was cut in a slide panel. This panel was then placed to pass through the cross section of the 10-inch tube and can be powered by the automatic sampler or moved manually. A diverter was then positioned on the center line of the 10-inch tube and 11 inches below the slide panel. To facilitate filming of various flow patterns and ve-

[6] Trade names are used in this publication solely to provide specific information. Mention of a trade name does not constitute a warranty of the product by the U.S. Department of Agriculture nor an endorsement over other products not mentioned.

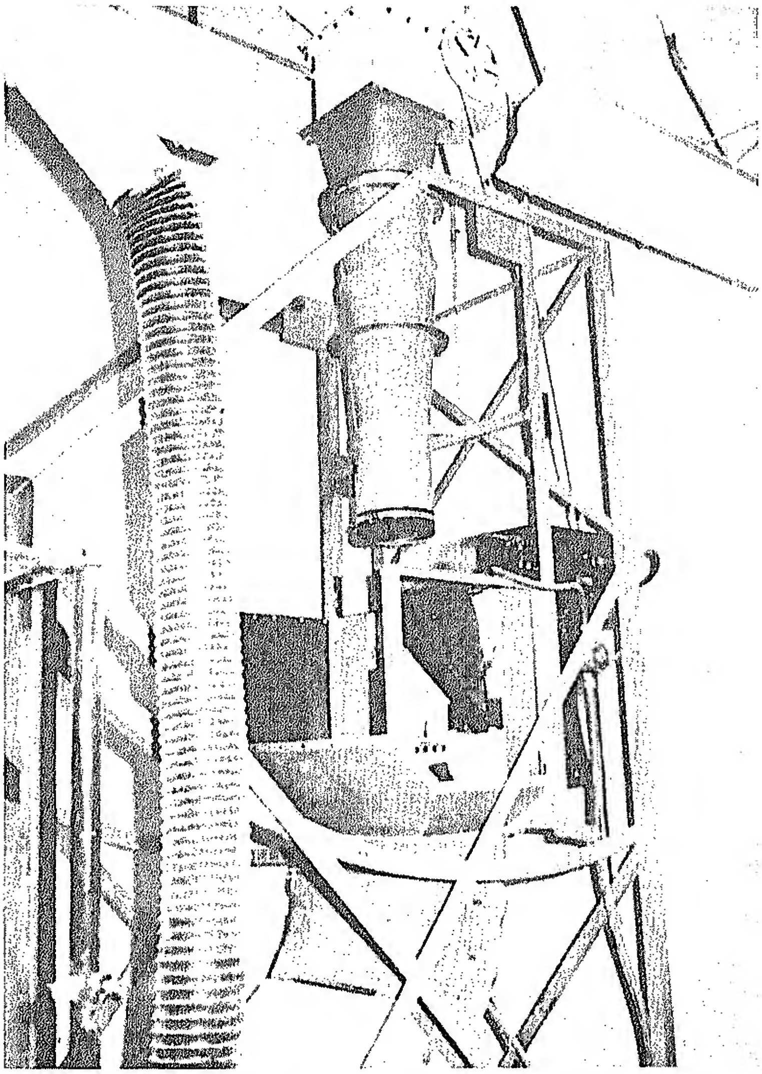


Figure 2.—Sampling apparatus in vertical position; spout angle of 90 degrees.

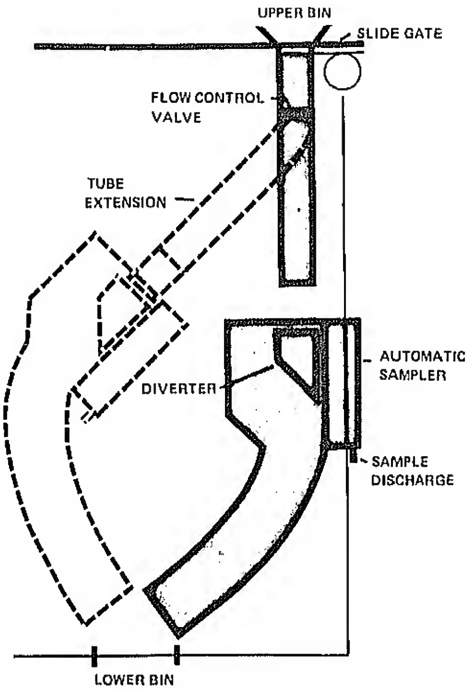


Figure 3.—Schematic of sampling apparatus with the spout in the 45 and 90 degree positions.

locity determinations, a diversion panel was placed to divert grain from the near half of the tube.

Diverters

Three commercial diverters, plus one diverter constructed here, were tested. Two of the commercial diverters were supplied by the Dean Gamet Manufacturing Company, and the other diverter was from the Strand Company (fig. 6). Diverters A and B had flat channel shapes; C and D had circular channel shapes. Internal volume, from the largest to the smallest, was A, D, B, and C. Diverter C originally had a circular discharge area. In later tests, C was modified by enlarging the discharge area (fig. 7). The body of diverter D was a composite of the other diverters. It had an entrance shape representative of another commercial diverter, which was not adaptable to the automatic sampler used in these tests.

Diverter entrances

The diverter entrance shapes used for wheat and corn are shown in figures 8 and 9. Shape I was made with 1/8-inch thick metal; the others with 1/16-inch thick metal.

Diverter entrance attachment

An attachment for holding diverter entrance shapes was added to the sample cutting device. The attachment was a holder 9 inches below the

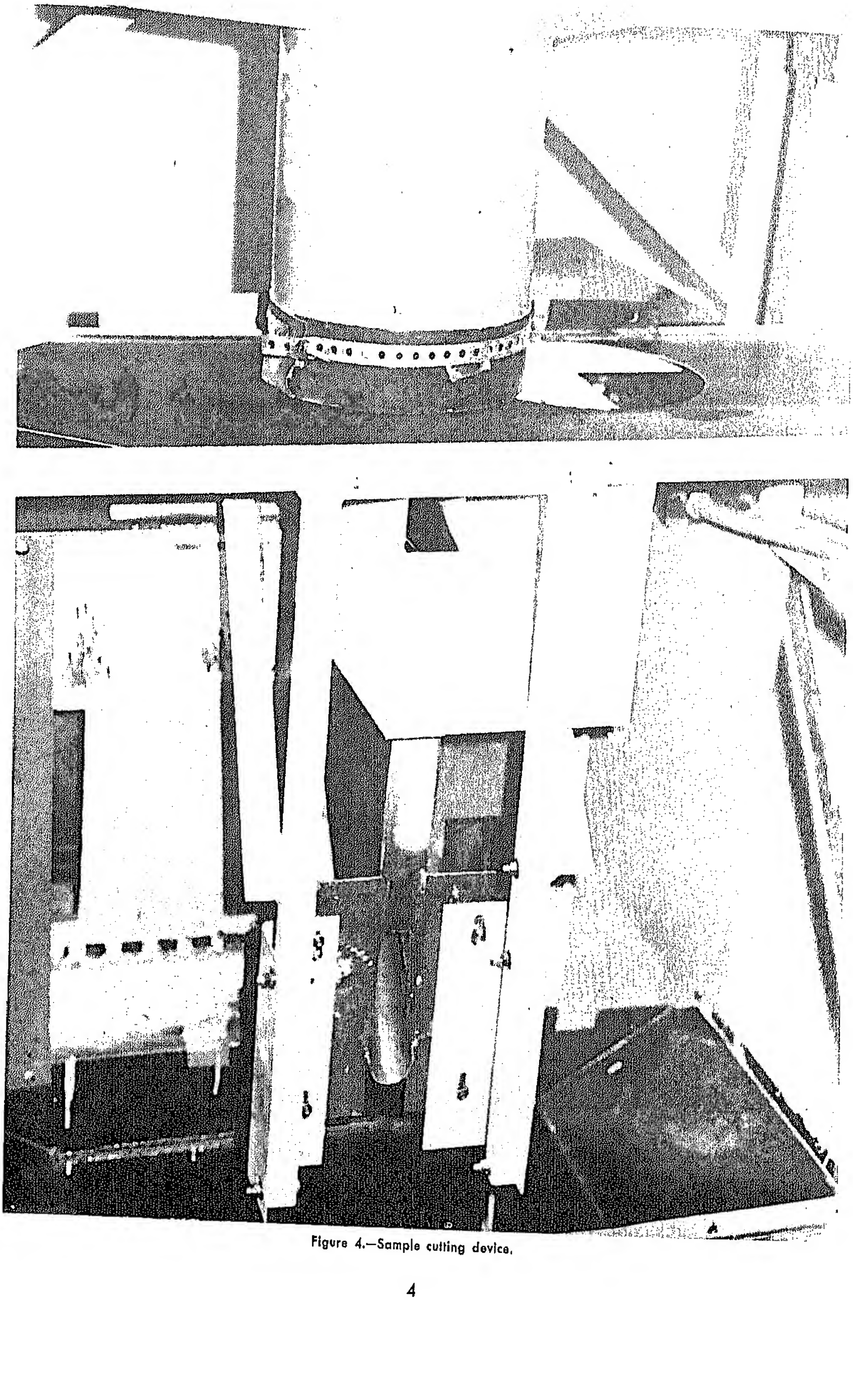


Figure 4.—Sample cutting device.

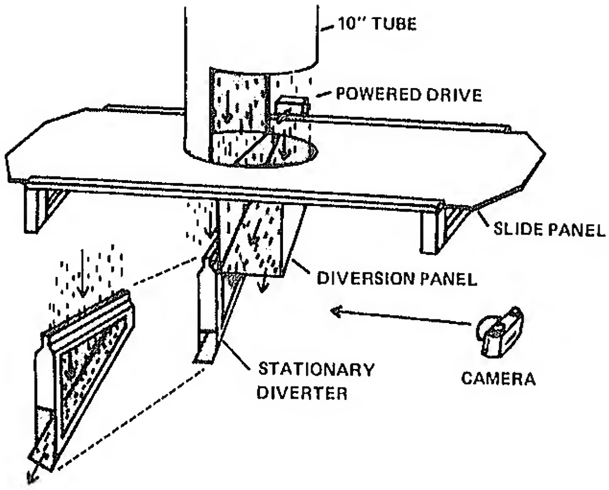


Figure 5.—Sample cutting device with a stationary diverter in place.

diversion panel (fig. 10). A piece of ¼-inch plexiglass was placed flush with the end of the cutter lips on the attachment. This facilitated photographing the grain flow patterns around the diverter entrances, especially the end views. To determine the average velocity of the grain at the diverter entrance, a horizontal grid was incorporated on the right side of this attachment. Figure 11 shows the diverter entrance attachment in position and figure 12 the diverter entrance attachment with camera and lights in position.

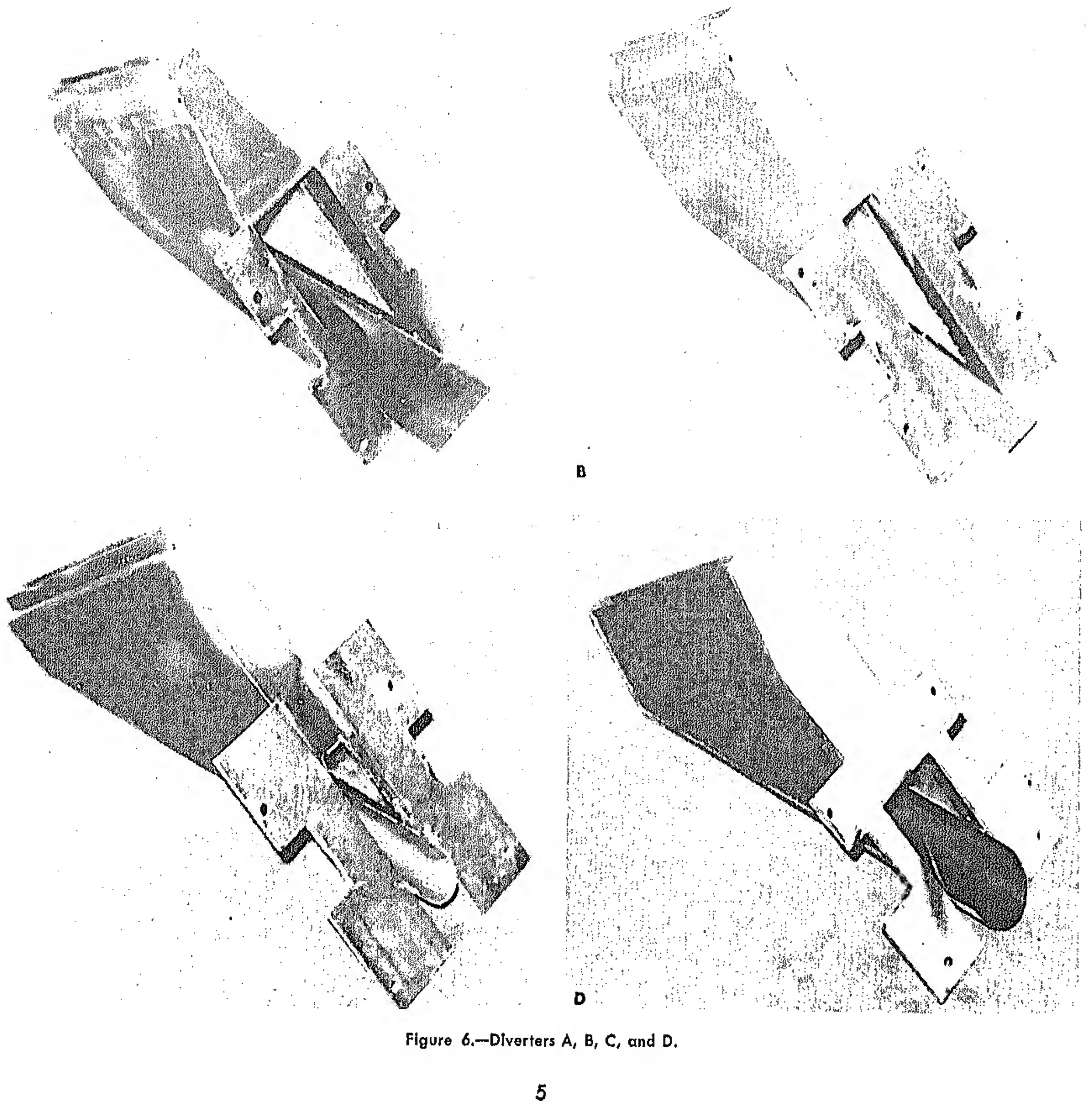


Figure 6.—Diverters A, B, C, and D.

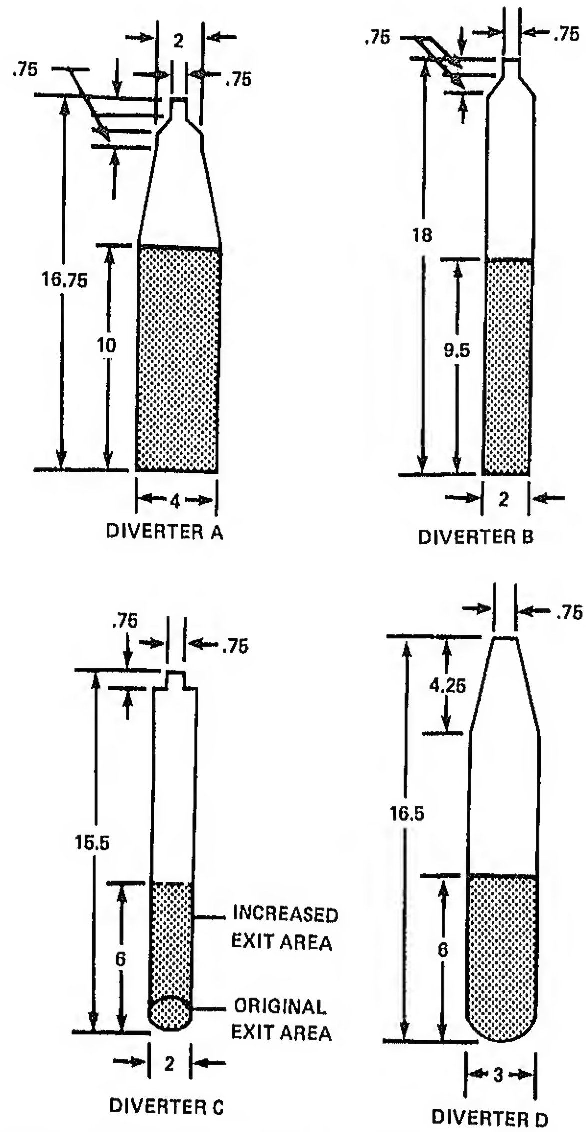


Figure 7.—End view of diverters A, B, C, and D. Shaded area is exit area.

Sample collection

Obtaining a desired flow rate was the first consideration in sample collection. Because of the variability of the flow control valve, a sequence of events was necessary to start the grain stream: First, the slide gate was opened to maximum; second, the flow control valve was opened to the desired setting; and third, the grain stream was allowed to run a specified amount of time depending upon flow rate before sample collection began. At low flow rates (4,000 lb/min) 45 seconds was ample time; although at high flow rates (8,000 lb/min), at least 90 seconds was required.

By allowing the grain stream to run, the "coring" velocity was stabilized. Even though the flow control valve was set at the same setting for various drops of the grain lot, the flow rate still varied. Therefore, when the grain lot was dropped the time was recorded to insure a known flow rate. Ten cuts through the grain stream by one diverter produced 10 increment samples. These samples were then weighed, recorded in order, and averaged to determine the representative sample weight for that flow rate and that diverter. The diverters were made so they could be placed on and taken off the transporter quickly. Therefore, more than one diverter could be tested during one drop of the grain lot.

Flow patterns within the diverter

Because there was little success in previous attempts (6,7) to photograph a diverter passing through a grain stream, the slide arrangement with the diverter held stationary was used (figs. 4 & 5). This was not meant to be a model of sample collection by a diverter passing through a grain stream but rather a means of determining the effect of a sample cut or grain passing through a diverter. Plexiglass was placed in one side of the diverter. One piece of plexiglass fit flush with the inside edges of the diverter, and an outer piece held the inner piece in place. The entrance shape was not affected by the plexiglass.

Three effects were photographed for each diverter: (1) with the slide connected to the transporter, one cut of grain was passed through the diverter; (2) same as (1), except the diverter exit was closed off, and the sample was weighed; and (3) the slide was adjusted manually to give maximum constant flow through the diverter. To start the grain stream again, both the slide gate and flow control valve were opened completely. The tube was allowed to fill before the slide panel was operated. The most uniform and controlled flow of grain was established by this method.

Flow patterns around entrance shapes

The apparatus for attaching entrance shapes (fig. 10) was used to determine the flow patterns around the entrance shapes that provided a representative end view of the grain entering the diverter. The flow patterns established by the shapes were photographed on the Hycam camera. Two results were desired: flow pattern around the entrance shape, and grain velocity at which these

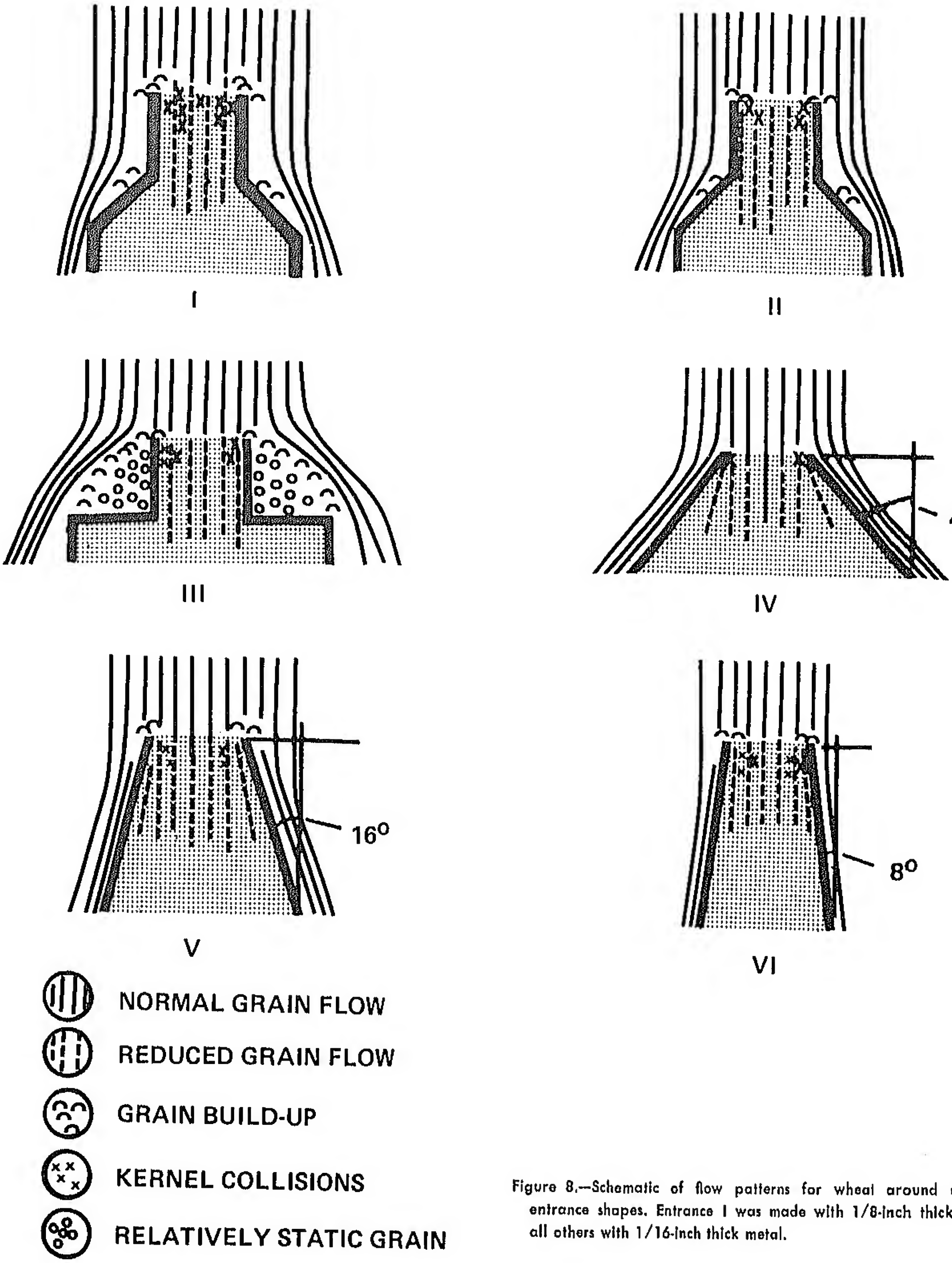
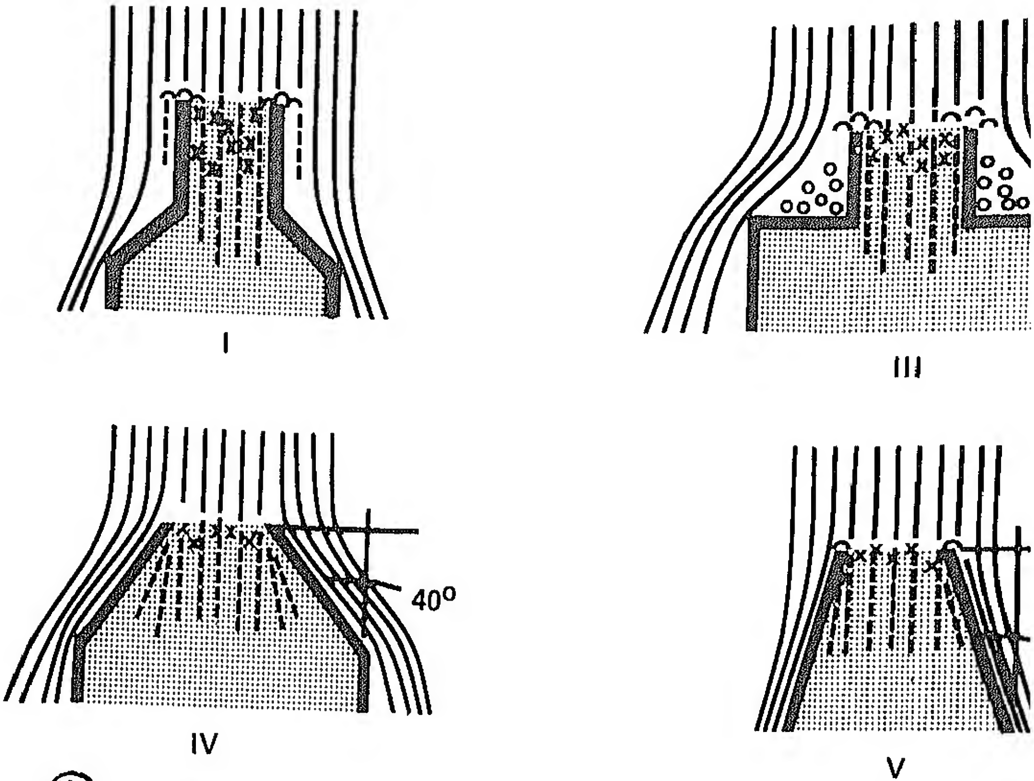


Figure 8.—Schematic of flow patterns for wheat around diverter entrance shapes. Entrance I was made with 1/8-inch thick metal; all others with 1/16-inch thick metal.

patterns developed. After starting the grain stream (as stated in the previous section), the slide was adjusted to give maximum constant flow past the diverter entrance. A ¾-inch width for the cutter entrance was maintained for all shapes studied. Plexiglass was placed at the edge of the cutter entrance to eliminate grain splatter and to provide a more consistent surface of grain for photograph-



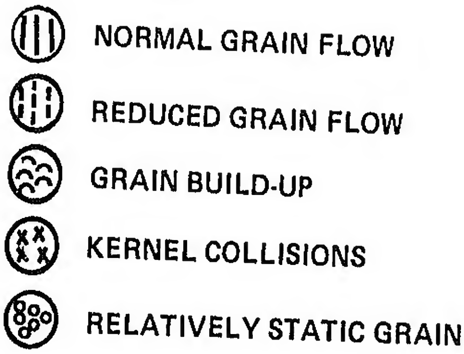


Figure 9.—Schematic of flow patterns for corn entrance shapes. Entrance I was made with 1/8 all others with 1/16-inch thick metal.

ing. Distance from the slide to the cutter entrance varied with the entrance shapes.

Velocity measurements

High-speed photography was used to determine the kernel velocity as it entered the diverter entrance (figs. 10 to 12). The horizontal grid with ½-inch spacings attached to the holder was on the same plane as the surface and, therefore, no correction had to be made to obtain true travel distance. A Hycam camera equipped with a light generator placed marks on the edge of the film at intervals of 10 milliseconds for time references. The camera was run at 1,000 frames per second. Figure 12 shows the camera, lights, and diverter entrance attachment in position.

An Optical Data Analyzer Projector view the developed film. The timing r film edge were used to determine whe was up to speed. The kernel velocit average velocity over a distance of up

Experimental procedure

The nature of this investigation was be qualitative rather than a quantit ment; therefore, the procedure for the was often determined by the previous c The investigation included four phases:

The first phase was to verify the s rameters by collecting samples with th mercial diverters at three flow rates an

angles. Flow rates for earlier work[7] ranged from 400 to 6,400 lb/min; flow rates for current work ranged from approximately 4,000 to 9,500 lb/min, which permitted us to relate the two sets of data and extend the conclusions.

The second phase determined the flow patterns that developed within a diverter as the diverter passed through a grain stream. Because various techniques were attempted previously (*6*) to photograph this event, all of which produced inadequate results, the sample cutting device (figs. 4 and 5) was designed and used. Using the indicated procedure with this device, the importance of body configurations was assessed. The three commercial diverters plus one constructed on site represented different body configurations and entrance shapes.

Entrance shape was found to be of additional interest from the results achieved by observing the flow patterns within the diverters. Therefore, in the third phase of the study an attachment was made

[7] Unpublished data reported under Cooperative Agreement No. 12-14-100-5557(51) between Cargill, Inc., and ARS, USDA, 1970.

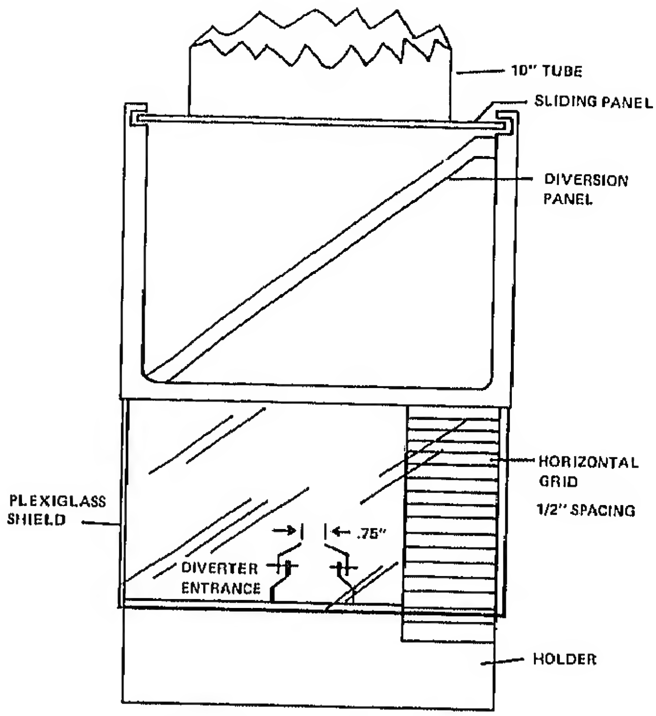


Figure 10.—Diverter entrance attachment.

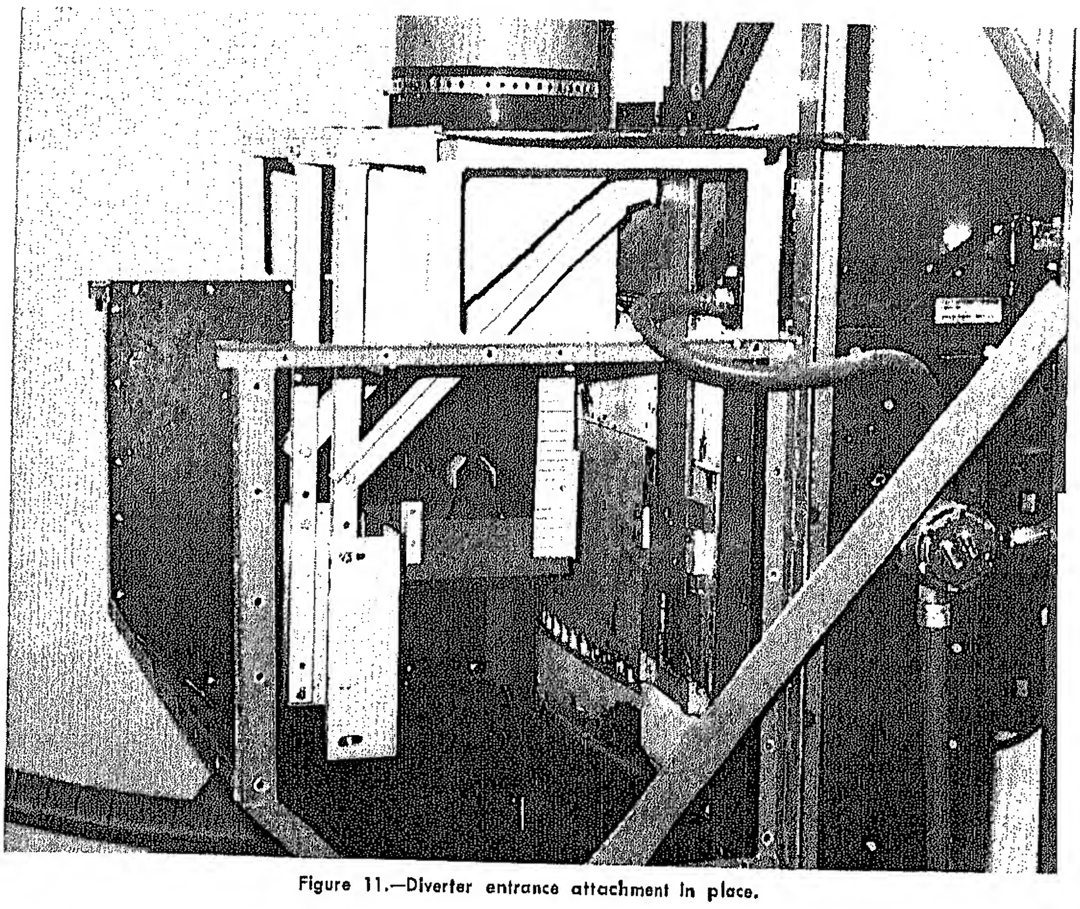


Figure 11.—Diverter entrance attachment in place.

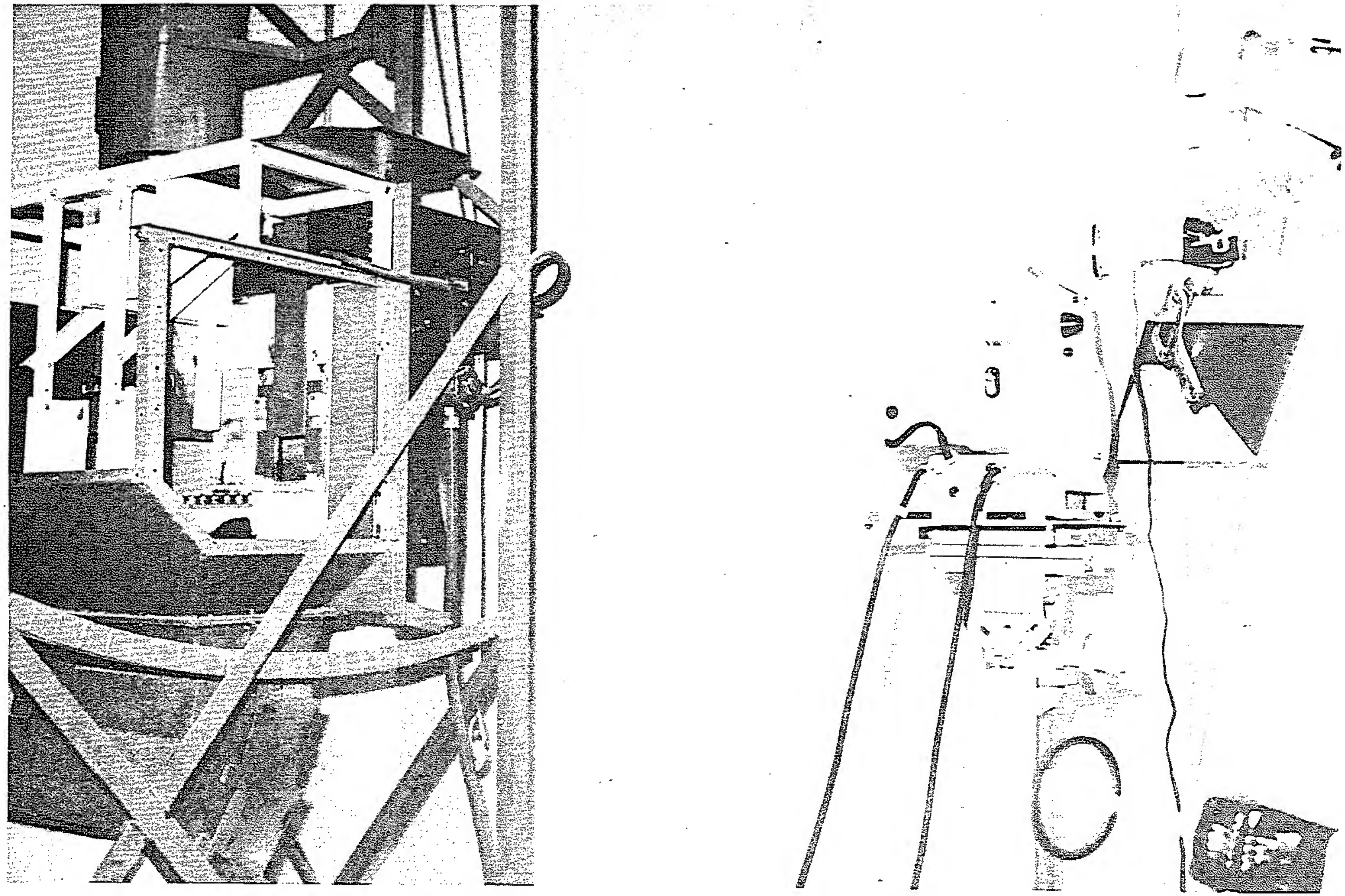


Figure 12.—Diverter entrance attachment with camera and lights in place.

to hold diverter entrance shapes using the sample cutting device. The shapes used for wheat are shown in figures 8 and 9 for corn. Following the above-described procedure of flow patterns for entrance shapes, a hypothesis was formed showing that the entrance shape affected the amount of sample collected and the degree of bias. The flow pattern films demonstrated the bias of various entrance shapes.

The fourth phase determined the effect of diverter entrance shape and body shape on amount of sample collected. Four diverter entrances (I, III, IV, and V, fig. 8) were used on diverter body A (fig. 7). To determine the effect of diverter body shape on sample weight, diverter C (same entrance shape as III) and diverter D (same entrance shape as V) were used.

As many known parameters as possible were held constant for all tests. Diverter traverse speed was 96 ft/min and diverter entrance width was ¾ inch. Sampling-spout angles were either 45° or 90° from horizontal. Effect of grain-kernel configuration was represented by corn and wheat for large and small kernels. Grain flow rates were adjusted to rates between 4,000 and 9,500 lb/min. Because flow through the control valve varied, precise flow rates could not be repeated. All diverters were used on the same transport device. Nonuniformity of grain flow was the least predictable parameter; therefore, we attributed sample weight variation primarily to varying densities of grain streams. Also attributing to varying grain stream density was the polishing effect on the grain resulting from handling it several times.

RESULTS

Sample weights (grams) of wheat and corn collected with the three commercial diverters (A, B, and C, fig. 7) were linearly related to flow rate (lb/min) when the sampling apparatus was in the vertical position (figs. 13 and 14). Sample weight and flow rate were linearly related for wheat when the sampling apparatus was rotated to the 45° position, but sample weight was less than at the vertical position.

At 45° the relation between sample weight and flow rate of corn became nonlinear at the higher flow rates. A greater reduction was shown in sample weight of the samples collected at 90° and 45° for corn than for wheat. The smallest samples were obtained using diverter B for wheat and corn.

General trends of the graph for wheat (fig. 13) indicate that the higher the flow rate, the larger the difference between diverters in the amount of sample collected with the sampler in the vertical position. This is in agreement with the work of Kramer (7) who reported less difference between diverters at lower flow rates. The important difference between the results for wheat and corn was that diverter C consistently collected more grain than diverter A with wheat, but diverter A collected more than diverter C (except for one case) with corn at a spout angle of 90°. In all cases diverter B collected the least amount of grain.

Samples were collected from the grain stream with the sampler alternating from left to right and the average weights of the odd numbered increment samples and the even numbered increment samples determined (table 1). The overall average effect of diverter travel direction based on the lighter of the two averages, expressed as a percentage of the heavier average weight, was 96 percent for all cases. Kramer (7) also reported a difference in sample weights as a result of travel direction. His explanation was that diverter velocity was controlled by gear ratio and motor r/min, which was not always ideally the same for both directions.

However, we measured diverter travel speed. No measurable difference was detected in the travel time required for the diverter to travel one direction as opposed to the other direction. The time required was 0.4 ± 0.01 seconds.

From these studies, diverter characteristics affecting sample bias and size of sample collected were observed: (1) the volume needed within the diver-

TABLE 1.—*Effect of diverter travel direction based on the average weight of the lighterweight samples of grain, expressed as a percentage of the heavier average sample for wheat and corn*[1]

Diverter	Lighterweight to heavierweight average						
	Wheat				Corn		
	Flow rate (lb/min)						
	2,953	3,908	5,515	7,668	3,215	5,091	7,636
A	97.3	98.1	98.8	98.6	94.0	98.0	98.6
B	94.6	96.2	96.3	99.4	99.3	95.1	97.0
C	88.9	89.3	91.2	97.5	91.7	95.8	98.3

[1] The automatic sampler was in the vertical position, spout angle 90°.

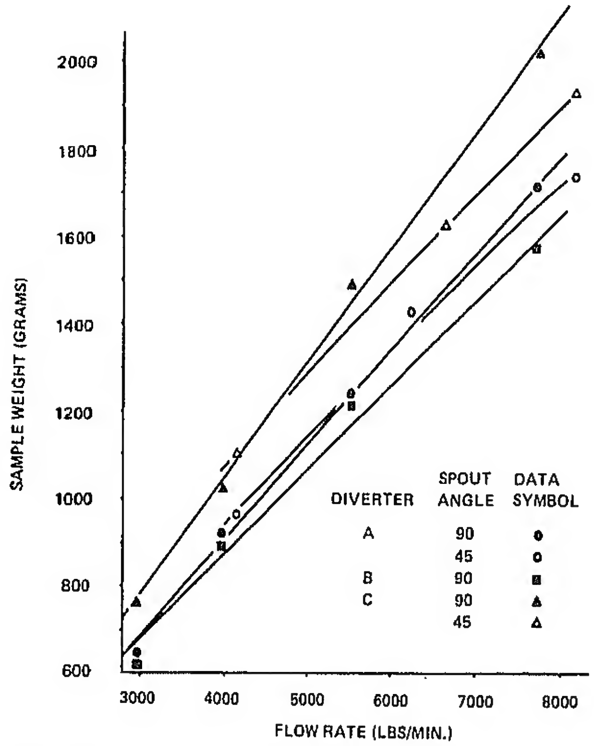


Figure 13.—Grain flow rates and sample weights of wheat for diverters A, B, and C at spout angles of 45° and 90°.

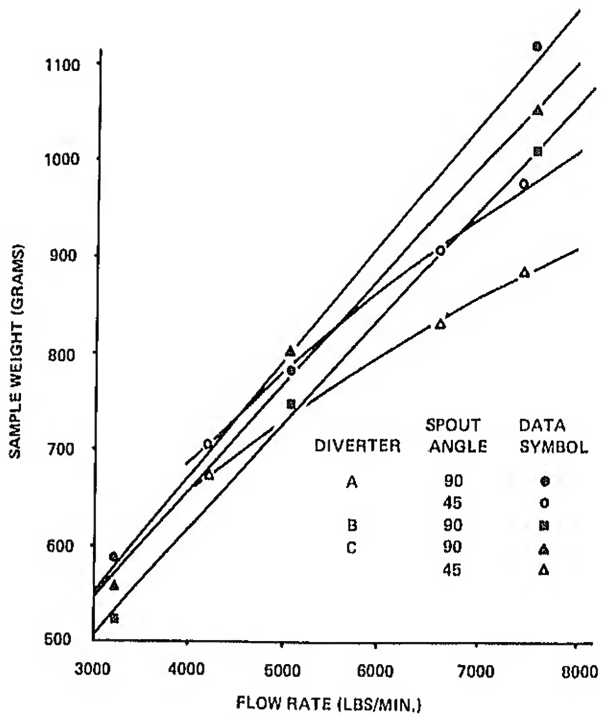


Figure 14.—Grain flow rates and sample weights of corn for diverters A, B, and C at spout angles of 45° and 90°.

ter to prevent clogging or overflow of the diverter, (2) the area required for the discharge point to prevent excessive buildup within the diverter, and (3) the effect of diverter entrance shape on sample size and quantity.

Flow patterns within the diverter

By holding the diverter stationary and simulating the movement of the grain tube passing over the diverter, the effect of one cut of grain passing through the diverter was observed and photographed. A relative comparison between sample weights incurred from actual sampling and those from the sample cutting device was made to determine if that photograph represented actual conditions. To determine the presence of excessive restrictions of grain within the diverters, a continuous grain stream was run through.

Figure 15 shows the schematic flow patterns for wheat within the diverters for three conditions:

1. Maximum level for one cut of grain passing through the diverter,
2. Grain level for one cut of grain with the exit closed off, and
3. Grain level under continuous run conditions.

The sample weights measured from condition b ranged in value from 2,000 to 2,300 grams of wheat. This was slightly heavier than those weights measured under actual sampling conditions. Diverters B and C had vertical side walls 2 inches apart. Grain build-up in these two diverters was excessive. Diverter C did not have the discharge area or depth of diverter B, and consequently overflowed under all three conditions. When diverter C's discharge area was increased as shown in figure 7, it did not overflow for one cut of grain (condition 1), but under conditions 2 and 3 it did. Diverters A and D had side walls 4 and 3 inches apart, respectively. These diverters had sufficient internal volume and discharge area. Conditions 1 and 2 for each of these two diverters were similar.

Figure 16 shows the schematic flow patterns for corn within the diverters for the same three conditions as for wheat. The range in weight of samples obtained under condition 2 was from 1,400 to 1,500 grams, which was more than the weight of samples taken under actual sampling conditions. For corn, all four diverters had ample internal volume and discharge area for one cut of grain to pass through; however, buildup was still noticeable for diverters B and C. Diverter C with its larger discharge area (fig. 7) still overflowed under

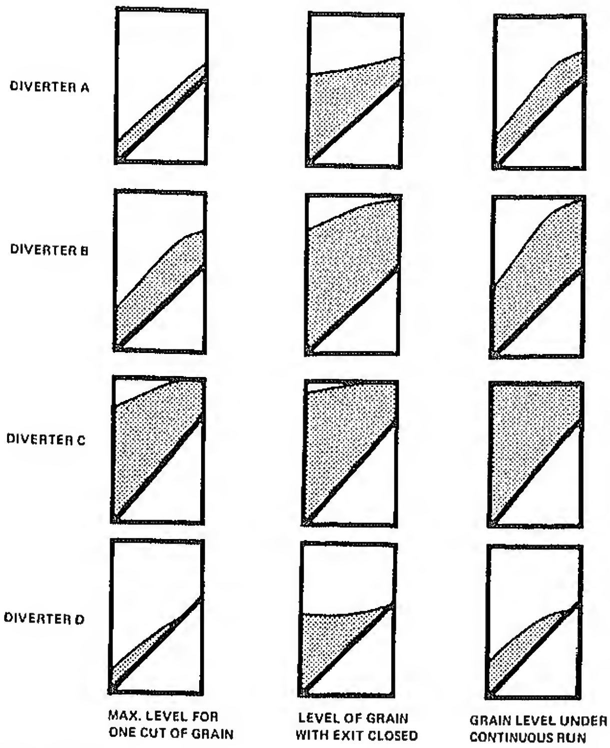


Figure 15.—Schematic of flow patterns of wheat in diverters, A, B, C, and D.

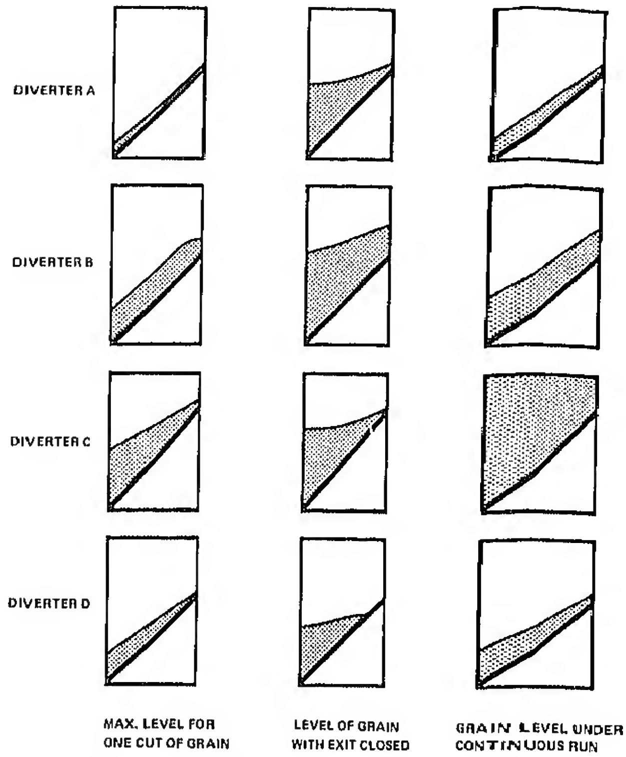


Figure 16.—Schematic of flow patterns of corn in diverters A, B, C, and D.

condition 3. Diverters A and D each showed similar grain flow patterns between conditions 1 and 3.

Flow patterns around the diverter entrance

Diverter entrance shapes and the schematic of the grain flow patterns around these entrances for wheat and corn are shown in figures 8 and 9.

The effect of metal thickness on grain flow patterns was observed in the wheat films in which a distinct difference was clearly seen between diverter entrances I (1/8-inch thick metal) and II (1/16-inch thick metal). Grain build-up on the leading edge of entrance I was greater than on II. A horizontal velocity component was introduced by grain striking the leading edge on each side of the diverter entrance area. Because the grain stream was kept from gaining immediate relief as it entered the diverter, these collisions formed a binding effect between the vertical metal strips of the entrance. The difference between the amount of congestion for entrances I and II is shown in figure 8. Corn kernels deflected into the entrance area to a greater degree than wheat. This was especially noticeable when corn kernels in the wheat lot struck the leading edge of the entrance. These kernels moved farther horizontally than the wheat kernels.

Entrance III and the entrance for diverter C were the same in metal thickness and dimension. When wheat was passed by entrance III, a buildup occurred on the ledges. This buildup extended to the leading edge of the entrance in a convex fashion. The overall flow pattern was similar to that produced by entrance IV. As corn was passed by entrance III, the buildup on the ledges was not as well defined as it was for wheat.

Entrances IV, V, and VI were basically the same. The variation was in the amount of angle at which the entrance sides were bent inwards from the vertical. This progression in angle variation was made to determine the approximate angle at which buildup on the leading edge would disappear. Entrance VI was turned inward 8°; V, 16°; and IV, 40°. Entrance V and VI reacted similarly to entrance I along the leading edge. Below the leading edge a degree of relief for the grain stream was provided as it entered the entrance area. Figure 8 shows schematically how the flow pattern drew together at the leading edge similar to that seen in fluid flow passing through an orifice. The

available width for grain to enter a diverter was decreased by this flow pattern, thereby decreasing the sample weight and possibly increasing the amount of bias.

Entrance IV produced the least amount of grain deflection on the leading edge. Immediate relief for the grain entering the entrance area was shown by a slight expansion on the underside of the leading edge for both grains. The flow pattern did not seem to draw together as it did for entrances V and VI. Corn deflected in the entrance area of IV to the point where flow was restricted slightly, but wheat flowed in this region with little interference. The change in grain direction as it struck the outer surfaces of the entrance was substantial, but the grain in the entrance area was not affected.

The corn flow patterns for the four diverter entrances (I, III, IV and V) were similar to that of wheat, but collisions between grain kernels in the entrance area were such that grain flow into a diverter would be restricted as shown in figure 9. Kernels of corn bounced in a zigzag pattern as they passed through entrances I and III. In entrances IV and V, the corn kernels deflected to a greater degree than wheat kernels.

The shape of the leading edge for entrance V was similar to B in figure 17. The effect of different metal strips on grain stream deflection was observed to improve upon this shape. Figure 17 shows

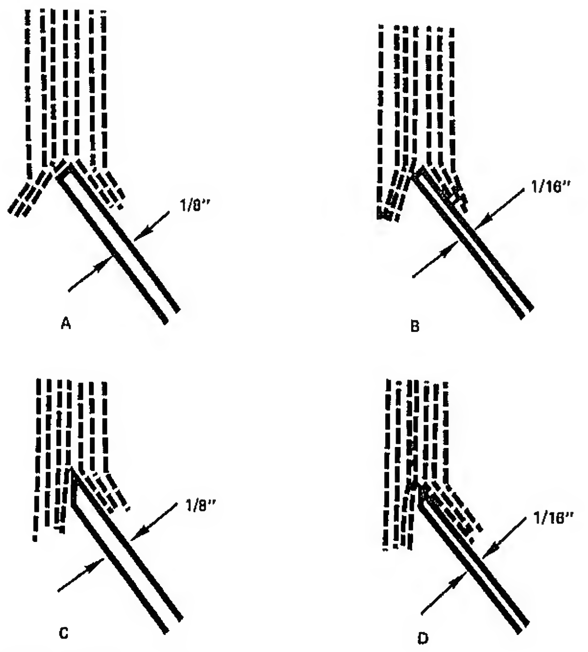


Figure 17.—Schematic of the leading edge effect on grain deflection for diverter entrance shape IV.

schematically the deflection produced by varying the thickness and leading edge shape. Thicknesses of 1/16 and 1/8 inch were the limits for metals in commercial use of diverters. Strips C and D produced the same flow patern; A and B flow patterns were altered by metal thickness. Considering commercial use, C would be more durable and produce no more deflection than D.

Damage to the grain as a result of the knife edge can not be determined intuitively. Actual sample analysis comparing results from a sharp knife edge to a slightly rounded edge is needed, which was beyond the scope of this investigation. The grain damage resulting from grain striking the outer portion of the diverter entrance decreases as the angle of impact decreases. Keller (5) showed total damage was reduced by 33 percent with impaction against a 45° angle steel surface compared to 90° angle surface.

Diverter entrance and body shape

The effect of diverter entrance shape and body shape on amount of sample collected from a grain stream was determined. With diverter A (fig. 7) entrance shapes I, III, IV, and V (designated A-I, A-III, A-IV, and A-V) were used; with diverters C and D entrance shapes III (designated as C-III) and V (designated as D-V), respectively, were used. All samples were collected with the sampling apparatus in the vertical position, spout angle 90°.

The results for grain flow rate versus sample collection weight for wheat and corn are shown in figures 18 and 19. The relation between the two variables was linear; however, the slopes were not the same.

In all cases entrance A-IV collected the largest amount of sample and A-I the least. The results filmed and observed from flow patterns around entrance shapes were supported by this difference in sample weight. Diverter A-IV had the least amount of turbulence or build-up in the entrance area, whereas A-I had the most. The other four diverters collected grain in a region between the limits set by A-I and A-IV. Their entrances correspondingly produced flow patterns beween those of A-I and A-IV with respect to interference at the entrance area.

Although diverter A-III and diverter C-III had different internal body shapes, the results of sample collection were similar for the collection of wheat and corn. Diverters A-V and D-V likewise collected similar amounts of grain within the range of flow

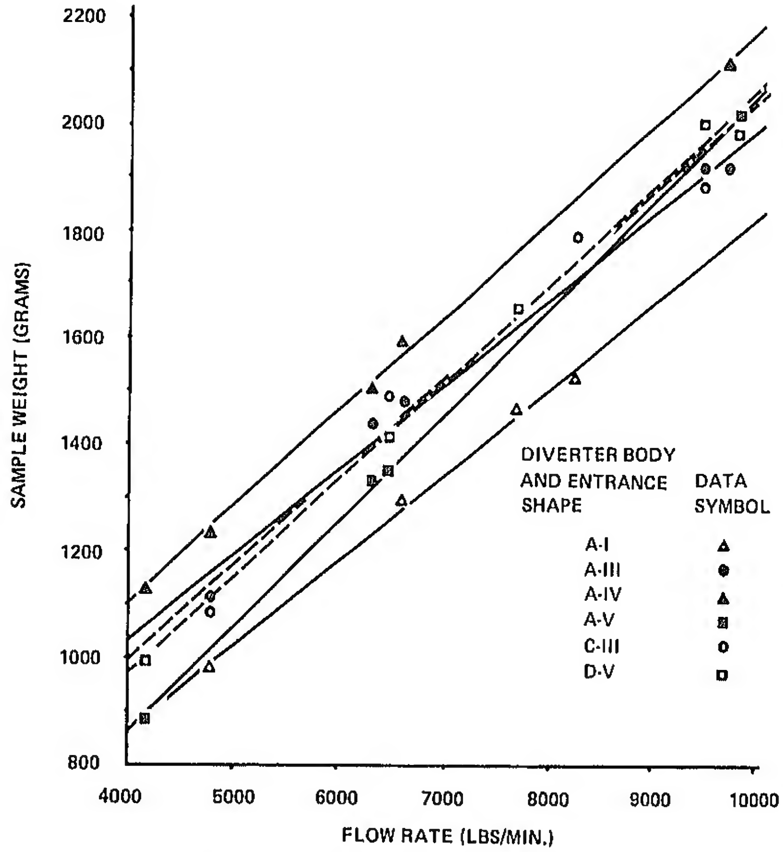


Figure 18.—Grain flow rates and sample weights of wheat for diverter bodies and entrance shapes A-I, A-III, A-IV, A-V, C-III, and D-V.

TABLE 2.—*Average sample weight ($\bar{x}$), standard deviation (s), and coefficient of variation (c.v.) for flow rates of wheat for diverter shapes I, III, IV and V mounted on diverter body A and diverters C and D. Sampler was in the vertical position; spout angle 90°.*

Diverter and entrance shape[1]	Variable	Flow rate (lb/min)[2] 4,170	4,776	6,300	6,437	6,580	7,691	8,225	9,400	9,708	9,870
A-I	$\bar{x}$ ....gram....		982			1,290	1,466	1,526			
	s ....gram....		13.2			30.8	48.1	57.2			
	c.v. ....percent....		1.3			2.4	3.3	3.7			
A-III	$\bar{x}$ ....gram....		1,110	1,439		1,484			1,919	1,896	
	s ....gram....		19.6	40.0		38.9			38.5	51.1	
	c.v. ....percent....		1.7	2.8		2.6			2.0	2.7	
A-IV	$\bar{x}$ ....gram....	1,129	1,231	1,499		1,598				2,123	
	s ....gram....	25.7	16.6	22.9		31.2				32.1	
	c.v. ....percent....	2.3	1.3	1.5		1.9				1.5	
A-V	$\bar{x}$ ....gram....	879		1,331	1,349						2,027
	s ....gram....	32.0		34.3	25.6						40.2
	c.v. ....percent....	3.6		2.6	1.9						2.0
C-III	$\bar{x}$ ....gram....		1,083		1,493			1,793	1,886		
	s ....gram....		9.5		50.8			34.8	23.8		
	c.v. ....percent....		.9		3.4			1.9	1.3		
D-V	$\bar{x}$ ....gram....	997			1,415		1,656		2,013		1,971
	s ....gram....	10.4			28.5		35.0		42.6		49.8
	c.v. ....percent....	1.0			2.0		2.1		2.1		2.5

[1] See figure 7 for diverter design and figure 8 for diverter entrance shape.

[2] Grain stream time limitations precluded testing all diverters at exactly the same flow rate.

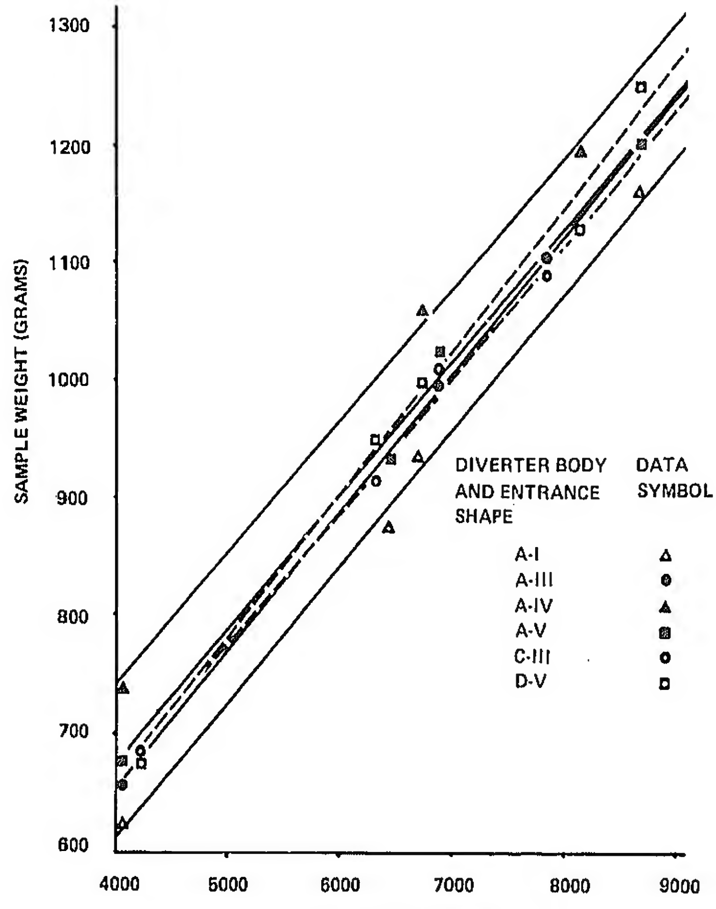


Figure 19.—Grain flow rates and sample weights of corn for diverter bodies and entrance shapes A-I, A-III, A-IV, A-V, C-III, and D-V.

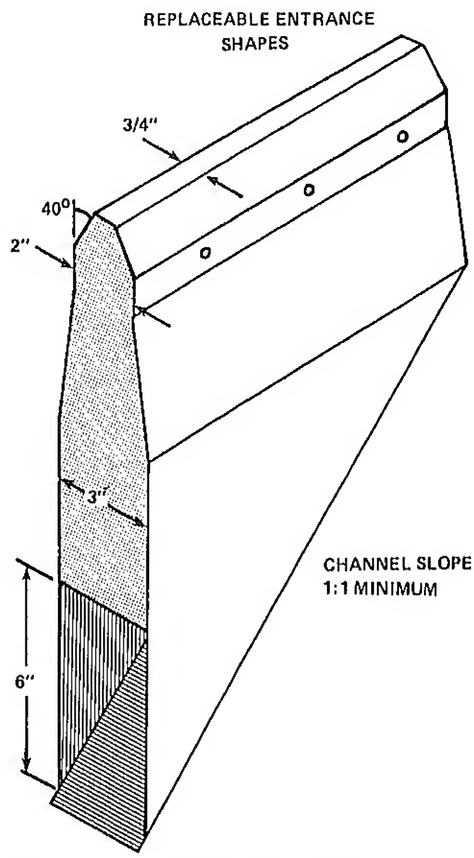


Figure 20.—Recommended diverter design for wheat.

rates studied. Figure 19 shows A-V collected less than D-V at the lower flow rates; however, the regression lines converge at the higher flow rates. Because diverter entrance shape was the same for each, internal diverter shape did not affect sample weight at the higher flow rates.

The average sample weight and standard deviation at each flow rate and grain type were calculated to determine the consistency for each diverter. Tables 2 and 3 show the results for wheat and corn. The amount of deviation for wheat tended to be greater at the higher flow rates with a few exceptions. Diverter A-IV was the most consistent in that the standard deviation varied little with respect to flow rate. There was less variation in the range of standard deviations for corn than for wheat. Average sample weights were also lower for corn compared to wheat at the same flow rates. All of the diverters had about the same degree of consistency for corn.

CONCLUSIONS

1. Flow rate and sample weight from all diverters for wheat and corn were linearly related over a range of 4,000 to 8,000 lb/min using the automatic sampler in the vertical position.

2. Body shapes of diverters used did not affect sample size under flow rates studied. To clear the diverter rapidly, the discharge area should be equal to or larger than the entrance area. Body shape should be wide enough and deep enough to allow the grain stream below the diverter entrance to expand without restriction and to prevent grain in the space opposite the discharge point from backing up to the diverter entrance area. For a ¾-inch entrance width, a minimum expansion of 2 inches

TABLE 3.—*Average sample weight ($\bar{x}$), standard deviation (s), and coefficient of variation (c.v.) for flow rates of corn for diverter shapes I, III, IV and V mounted on diverter body A and diverters C and D. Sampler was in the vertical position; spout angle 90°.*

Diverter and entrance shape[1]	Variable	Flow rate (lb/min)[2]								
		4,012	4,200	6,300	6,428	6,702	6,848	7,778	8,077	8,630
A-I	$\bar{x}$ ....gram	617	647		875	937				1,165
	s ....gram	22.1	23.4		25.4	33.5				38.9
	c.v. ....percent	3.6	3.6		2.9	3.6				3.4
A-III	$\bar{x}$ ....gram	656					998	1,106		
	s ....gram	25.9					24.1	24.5		
	c.v. ....percent	3.9					2.4	2.2		
A-IV	$\bar{x}$ ....gram	739				1,063			1,197	
	s ....gram	17.5				35.5			28.0	
	c.v. ....percent	2.4				3.3			2.3	
A-V	$\bar{x}$ ....gram	675			93.5		1,028			1,204
	s ....gram	19.3			37.5		25.6			25.1
	c.v. ....percent	2.9			4.0		2.5			2.1
C-III	$\bar{x}$ ....gram		683	916			1,008	1,090		
	s ....gram		17.1	31.5			34.4	33.9		
	c.v. ....percent		2.5	3.4			3.4	3.1		
D-V	$\bar{x}$ ....gram		673	955		1,000			1,131	1,253
	s ....gram		19.2	33.0		26.5			28.4	36.4
	c.v. ....percent		2.8	3.5		2.6			2.5	2.9

[1] See figure 6 for diverter design and figure 9 for diverter entrance shape.
[2] Grain stream time limitations precluded testing all diverters at exactly the same flow rate.

is needed below the diverter entrance area. Body width depends on the vertical depth of the diverter; that is, to maintain the same capacity, a shallow diverter requires a wide body.

3. Entrance shape of diverters was the most important factor studied. Flow patterns around the diverter with various entrance shapes produced an effective entrance width that governed the size and possibly the bias of the sample. Deflection of grain on the leading edge and congestion in the diverter entrance area decreased as the sides of the diverter entrance were turned inward. Of the angles studied, diverter entrance angle of 40° (entrance shape IV, fig. 8) produced the best flow pattern. Diverter entrance width of ¾ inch was adequate for wheat kernels but not for corn kernels. Corn kernels deflected more than wheat kernels.

4. Diverter with body A (fig. 7) and entrance shape IV (fig. 8) produced the largest samples. Grain did not build up on the leading edge of the entrance and the grain stream was not constricted. Coefficient of variation showed that performance of the diverter with diverter entrance body A, shape IV, was consistently as good as or better than that of other diverters tested.

5. Based on this study and previous data (*6,7*), the following guidelines are proposed for the design of a diverter:

a. Make entrance width ¾ inch for wheat, approximately 1⅛ inch for corn.
b. Allow at least 2 inches below the leading edge to prevent binding in the entrance
c. Have at least a 3-inch uniform body to prevent buildup of grain in the di and to allow rapid discharge.
d. Have slope on the bottom of the diver least 1:1. Channel shape can be either ci or flat.
e. Use entrance angle of 40° from the ve

Figure 20 illustrates a diverter designed for based on these guidelines.